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ABSTRACT

The purpose of this study was to compare the effectiveness of two instructional approaches on mildly handicapped and nonhandicapped students' science achievement. Students were assigned at random to one of two conditions: (1) direct instruction; and (2) discovery teaching. The content of the lessons remained constant across conditions and focused on such concepts as displacement, floatation, variable, controlled experimentation, and scientific prediction. Results showed that students in both groups learned equally well as measured by an immediate posttest. However, students in the discovery teaching condition outperformed their direct instruction counterparts on a retention test administered two weeks after the posttest. Finally, learning disabled students in the discovery condition performed better than their direct instruction counterparts on a performance-based measure designed to assess generalization. Implications for research and practice are discussed. (Author)

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Science Instruction for the Mildly Handicapped: Direct Instruction versus Discovery Teaching

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Running Head: Discovery versus direct

We gratefully acknowledge and thank the administrators and teachers in Schaumburg Community Consolidated School District 54, Schaumburg, IL, for their permission and assistance. This research could not have been conducted without the cooperation of these people: Dr. Eleanor Thorsen, Assistant Superintendent; Mr. Larry Small, Science/Health Curriculum Coordinator; Mrs. Mary Salee, Special Education Curriculum Coordinator; Mr. Terrance Baranowski, Principal, Campanelli School; Mr. Marvin Husby, Principal, Einstein School; Mrs. Patricia McConnell, Principal, Hanover Highlands School; and the teachers at Campanelli, Einstein, and Hanover Highlands schools.

Abstract

The authors' purpose in this study was to compare the effectiveness of two instructional approaches on mildly handicapped and nonhandicapped students' science achievement. Students were assigned at random to one of two conditions: a) direct instruction, and b) discovery teaching. The content of the lessons remained constant across conditions and focused on such concepts as displacement, flotation, variable, controlled experimentation and scientific prediction. Results show that students in both groups learned equally well as measured by an immediate posttest. However, students in the discovery teaching condition outperformed their direct instruction counterparts on a retention test administered two weeks after the posttest. Finally, learning disabled students in the discovery condition performed better than their direct instruction counterparts on a performance-based measure designed to assess generalization. Implications for research and for practice are discussed.

Science Instruction for the Mildly Handicapped: Direct Instruction versus Discovery Teaching

The enactment of PL 94-142 has fueled a major emphasis on preparing mildly handicapped students to succeed in mainstream classroom settings. Bolstered by the recent discussion pertaining to the regular education initiative (Will, 1986), the goal of integration is stronger than ever. Lacking, however, is a solid research base which indicates effective instructional techniques that are appropriate for use in integrated settings and targeted at specific curricular areas.

Science is one curricular area in which children may be mainstreamed for instruction. Our observations and work with Chicagoland school districts led us to conclude that mildly handicapped students often receive science instruction in the general education class. However, a review of the research indicates that scant attention has been devoted to this issue. For example, Lesson, Budzinski, Karch and Van Acker (1989) searched six major journals in special education from the years 1978 to 1985 and found only three articles that discussed science teaching with learning disabled (LD) students.

Recently, a small, but growing, body of research has been reported which addresses the impact of various instructional techniques on the performance of mildly handicapped students in science. For example, in a series of studies, Mastropieri, Scruggs, and their colleagues compared the impact of various instructional strategies, most notably mnemonic instruction, free study, direct questioning, and direct instruction on mildly handicapped children's memorization of facts. They found that mildly handicapped students who received mnemonic instruction consistently outperformed their peers who received instruction under free study,

direct questioning, and direct instructional conditions (e.g., Mastropieri, Scruggs, McLoone & Levin, 1985).

Work reported by Darch and Carnine (1986) offers a second example. These investigators examined the effectiveness of two instructional approaches on LD students' ability to comprehend social studies and science content. A visual spatial display, used as an advance organizer, was compared to an approach in which content was presented via text materials. In both conditions the students were taught in groups and were given explicit study strategies. The findings indicated significant positive effects on probe and posttest measures for the group taught under the visual spatial display condition. In addition to these measures, students were given a transfer test to determine if the visual display group would transfer earlier study skills when confronted with a novel, but appropriate task. Results indicated no significant differences on the transfer test. Hence, these results suggest that on measures of literal comprehension of science content, a visual spatial display was a relatively effective instructional approach.

Whereas these studies opened a new area of research in learning disabilities and provided valuable information in regard to effective science instruction for the mildly handicapped, the generalizability of their results to the regular classroom is limited. First, in the majority of these studies only handicapped students composed the samples. The relative impact of the instructional approaches on nonhandicapped students was not explored. Second, the instructional materials employed were designed specifically for the research and are not readily available to classroom teachers. Finally, instruction was limited to the memorization of facts or the literal comprehension of science content.

Research on "best practice" in science instruction for mildly handicapped children in mainstreamed classrooms needs to be expanded to include children's process skill development, conceptual understanding, problem solving, and the ability to generalize; these are skills considered of central importance by science educators.

There are two primary competing hypotheses concerning what constitutes "best practice": discovery teaching and direct instruction. Advocates of a discovery teaching approach to science maintain that phenomena should act as catalysts which initiate students' questions, processing, concept development, and extended explorations. In this way, students are actively engaged in gathering data, generating and implementing solutions, and observing their consequences. The majority of instructional time - 70% to 80% - is devoted to hands-on activities. The remaining time is taken up with giving directions, comparing data, and engaging in discussions that stem from experimental results. Instruction is focused on the learners, and the teacher functions as a guide and facilitator in this process (Cain & Evans, 1984).

Whereas discovery teaching tends to be child-centered, direct instruction systems can be characterized as teacher focused (e.g., Rosenshine & Stevens, 1986). Typically, these systems are carefully structured to include several phases. The teacher: (1) Presents, demonstrates, and/or models specific skills, concepts, and behaviors; (2) supervises students while they practice the ideas or skills presented; and (3) provides continuous feedback to students while simultaneously encouraging them to be actively involved. The notion is that the acquisition of targeted skills and concepts is enhanced when students receive continuous, corrective feedback. Finally, the teacher evaluates individual performance frequently and gives individual feedback.

The two instructional approaches described above are each supported by a large body of research. Direct instruction techniques have been shown repeatedly to correlate with achievement, particularly with children identified as low achievers (e.g., Brophy & Good, 1986). These findings, however, are limited to basic skill instruction in reading and mathematics. Similarly, a hands-on, discovery approach to teaching and learning science has been found to enhance understanding of concepts, development of science process skills, and attitudes toward science (cf. Shymansky, Kyle, & Alport, 1983; Bredderman, 1985). Its

success with mildly handicapped students, however, has not been explored.

Furthermore, research suggests that both direct instruction systems and discovery teaching approaches may be effective in producing generalization (Ellis, Lenz, & Sabornie,1987; Palincsar & Brown, 1984). But teaching approaches appropriate for use with the mildly handicapped and effective in producing generalization of newly acquired science processing skills remain to be documented.

Purpose

The authors' purpose in this study was to test the relative effectiveness of the discovery and direct approaches on the acquisition of science concepts and skills by integrated groups of learning disabled, behaviorally disordered, and nonhandicapped students. By examining the efficacy of the direct and discovery approaches, the authors sought to answer the following research questions: (1) Do mildly handicapped and nonhandicapped students exhibit greater science achievement under direct instruction or discovery teaching? (2) Do mildly handicapped and nonhandicapped students retain such achievement better under direct instruction or discovery teaching? (3) Do mildly handicapped and nonhandicapped students exhibit greater generalization of a science process skill under direct instruction or discovery teaching? (4) Is the achievement of nonhandicapped children affected when they work with handicapped children under direct instruction and discovery teaching?

Method

Subjects

The participants were students in grades 4-6 in three elementary schools in a large public suburban school system northwest of Chicago. All learning disabled (LD) and behaviorally disordered (BD) children who normally received science instruction in the

general education setting and who were granted parental permission to participate were included. Hence, ten (10) LD and six (6) BD students participated. In addition, counterparts in the same grade who were granted parental permission were randomly assigned to cells to fulfill the design of the study. A total of 138 students participated; seven youngsters were dropped due to excessive absences. Thus, 131 children completed the study. Data from 24 of these students were omitted from the analysis due to improper pretest administration; thus, 107 cases were analyzed. A description of the sample by grade, gender, and handicapping condition is given in Table 1.

Insert Table 1 about here

The LD subjects were classified by evaluation teams composed of teachers and psychologists from the schools the subjects attended. The school district criteria for classification as LD is in compliance with Illinois and federal guidelines which include fulfillment of the following criteria: (1) The student demonstrates intellectual potential at the low average range or higher on an intelligence test; (2) the student exhibits a measured processing deficit as well as a discrepancy between potential and achievement; (3) the learning problems are not due to other handicapping conditions or to cultural or economic disadvantage (Learning Disability Criteria, Schaumburg Community Consolidated School District 54, 1984).

The BD students were classified according to local school district criteria and to PL 94-142. According to school district guidelines, "A behavior disordered student is one who exhibits chronic pervasive behaviors in the school setting which significantly impede the student's educational progress. Such behaviors are of long duration, during which time, appropriate (documented) interventions have been ineffectual in enabling the student to modify such behaviors" (Definition of Behavior Disorders, Schaumburg Community Consolidated School

District 54, 1984).

Experimental Design

Within each school, handicapped students were randomly assigned to one of two treatments, direct instruction or discovery teaching. Selecting peers in the same grade as each handicapped student, the researchers then randomly assigned two nonhandicapped students to each handicapped student to form a triad. Thus, the five different types of students in this study were: (1) LD students (2) BD students; (3) nonhandicapped students who had an LD student in the triad; (4) nonhandicapped students who had a BD student in the triad; and (5) nonhandicapped students who had worked with nonhandicapped triad members. The general research design therefore was a 2 x 5 factorial design with two instructional methods and five types of student membership in the triad learning groups.

Science Content

The students in each condition were taught the same content. The major purpose of the lessons was to learn the process called controlled experimentation, one that is fundamental to scientific investigation. The concept of controlled experimentation was dichotomized into two broad areas of understanding: (1) a variable can be manipulated and, hence, can effect the outcome of an experiment; and (2) by changing only one variable at a time (while holding all others constant), the scientist creates the opportunity to establish cause and effect relations and make predictions.

By using "rafts" and focusing on factors related to the amount of weight a raft can support in water, the concept of controlled experimentation was presented. Specifically, the learning objectives were focused on: understanding the notion of displacement and flotation; the importance of balancing weight on a raft; the effect of manipulating a specific variable, such as thickness, on the amount of weight a raft will support in water; the use of controlled experimentation; and the relationship between controlled experimentation and scientific

prediction. The use of "rafts" to facilitate students' understanding of controlled experimentation can be found in a science curriculum entitled Science Activities for the Visually Impaired/Science Enrichment for Learners with Physical Handicaps (SAVI/SELPH) (Malone, DeLucchi, & Thier, 1984). SAVI/SELPH was developed at and published by the Center for Multisensory Learning, Lawrence Hall of Science, University of California at Berkeley.

Instruction

All instruction occurred in a quiet setting in the school. Students were taken from their classrooms in their triads to the learning setting and were given the assigned instruction by the same male experimenter, who was blind to the types of membership represented by the students. Treatment consisted of five sessions, with each session lasting from 40 to 60 minutes. All sessions were audiotaped. After the initial session, the first author selected tapes at random, listened to them, and verified that each type of instruction was implemented as planned. This procedure was repeated for subsequent sessions.

Although the content of the lessons was held constant, the manner in which the information was organized for instruction differed. That is, the content was conveyed via two different instructional approaches, direct instruction and discovery teaching. Both conditions were semiscripted in order to create consistency across triads within a condition.

Discovery Teaching Condition. Various renditions of discovery teaching have been offered. What is common to these renditions is a basic set of assumptions about the acquisition of knowledge. A discovery teaching approach is based on the assumption that children construct knowledge about their world. That is, through meaningful interaction with their environment, children construct concepts and ideas as well as develop a greater understanding of the world in which they live. Advocates of a discovery teaching model do not view children as passive recipients of information, but, instead, view them as active participants in the process of acquiring knowledge. Therefore, discovery teaching approaches are characterized by the use of

activities that encourage children to engage in such processes as identifying important questions, gathering data to respond to those questions, brainstorming solutions to problems, manipulating materials,and observing consequences. The discovery teaching lessons designed for this study were based on these basic assumptions and are described below.

Students were pretested at the beginning of the first session prior to instruction. In session one, students explored the notion of displacement and why objects float or sink using the SAVI/SELPH materials. In session two, the students used the materials to discuss the relationships among such concepts as displacement, balancing weights on a raft, and thickness of a raft. In session three, the students used thick and thin rafts to conduct experiments on the amount of weight each could hold. In session four, they made and tested predictions as to the amount of weight that a medium size raft could hold. At the close of session four the students took the posttest. Two weeks later the experimenter returned and administered the retention and generalization tests in the fifth session.

Direct Instruction Condition. Direct instruction models are based on a different set of assumptions about learning and the acquisition of knowledge. The primary underlying principle is that knowledge resides with the teacher and that it is the teacher's responsibility to transfer that knowledge to students. In order to operationalize this principle, direct instruction systems typically include teaching phases where the teacher presents, demonstrates, and/or models specific skills, concepts, and behaviors. Students have the opportunity to observe and ask questions. A second basic assumption is that students practice what they have learned. This practice can take many forms: boardwork, worksheets, responding to questions at the end of a chapter, etc. What is important is that initial practice sessions are under the teacher's direct supervision so that corrective feedback can be given. As the students' skill level increases, practice is completed under indirect teacher supervision to provide the student the opportunity to practice independent of the teacher's guidance. Third, in all direct instruction approaches a

prevailing notion is that learning is enhanced when students receive feedback as to the accuracy of their performance. Continuous, corrective feedback facilitates the acquisition of targeted concepts. Finally, the students' level of skill acquisition and knowledge are evaluated at frequent intervals. (For examples and discussion, see Rosenshine, 1986; Brophy and Good, 1986; and Deshler andSchumaker, 1986.). These basic assumptions created the foundation on which the direct instruction lessons for this study were built. The specific instructional phases infused into this series of science lessons were: Pretest; Advance Organizer; Presentation of Content; Demonstration/Modeling of Content; Guided Practice; Independent Practice; and Posttest.

Specifically, students were pretested at the beginning of the first session, prior to the presentation of the first lesson. The content of the lessons followed the same sequence as the discovery lesson. At the beginning of each lesson the students received an advance organizer which informed them of the purpose of the lesson and, for all but the first, reviewed concepts and skills presented in previous lessons. The experimenter then demonstrated the specific concept or skill with the SAVI/SELPH materials. Practice activities followed. Worksheets developed specifically for the lessons were used as practice activities. These worksheets required written responses and reinforced the concepts and skills presented in the demonstration phase. Worksheet questions addressed such notions as displacement, balancing of weights on a raft, the influence of the thickness of the raft on the amount of weight supported by the raft, and the capacity to make scientific predictions when all factors were held constant except one. In the initial practice phase, students received considerable guidance from the experimenter. In the final practice phase, students worked independently. All worksheet material was read to the students to control for differences in reading ability. Subjects were given immediate feedback with respect to their performance, particularly on the worksheets. The posttest was administered at the end of session four, after the last lesson was completed. The experimenter returned two weeks later and administered the retention and generalization

test.

Instruments

Two experimenter-developed assessment devices were constructed for this study. Short descriptions of each measure follows.

Written Test. A 20-item science test was constructed specifically for this study. Items were true/false, matching, and multiple choice in format and were designed to test specifically the concepts and skills presented in the lessons. In addition, the items assessed a broad range of difficulty, including acquisition of factual and inferential knowledge. All test items were read aloud to the students to control for differences in reading ability. This written test was used as a pretest, posttest, and measure of retention.

Generalization Test. A performance-based assessment procedure was constructed to determine the degree to which students had generalized the scientific process learned in the lessons. The specific purpose of the activity was for the student to determine, through the controlled experimentation process, the variable that affects the length of time it takes for one complete swing of a pendulum. The procedure was based on Piaget's Pendulum task (Inhelder and Piaget, 1958). Using a pencil, string, and masking tape, the experimenter constructed a pendulum. Also, steel washers were available for use by the student to alter the weight of the pendulum. The student was first asked to state the variables that might make a difference in the number of oscillations in a given time span. After receiving a set number of probes, the student was told one or more of the following variables if he/she had not mentioned them: length of string, weight of washer, height of drop, and force of push. In the second step of the activity, the student was asked to test the effect of each of these variables by conducting an experiment. This performance-based task was administered individually, two weeks after the last lesson.

Coding of the Generalization Test. The entire procedure was audiotaped for coding and scoring. After listening to the exchange between the student and experimenter, the student

was assigned a score in the following manner. First, the number of variables the student generated in response to the first question was counted and recorded. Next, the student was assigned to one of four categories. These categories represented variation in performance along two continua: (1) an understanding that controlled experimentation requires that the effect of only one variable be observed at a time (e.g., the impact of both length of string and weight of washers can not be evaluated simultaneously on the number of swings in a given time span); (2) an understanding that in order to determine the effect of a manipulated variable, a comparison must be made of its effects on the dependent variable at distinct levels (e.g., when assessing length of string, compare at least long and short lengths on the number of complete swings in a given time span).

Using these continua as a guide, students were assigned to one of four categories. Students assigned to category A exhibited the least amount of knowledge regarding the use of controlled experiments. Typically, they offered statements that indicated no understanding of the process, and, hence, were not able to do the task. These students were awarded one point. Category B students completed the task but required considerable guidance from the experimenter. The students received frequent reminding that comparisons must be made when assessing the effect of a variable and that all variables but one must be controlled when conducting an experiment. These students received a score of two points. Students assigned to category C completed the task and received minimal guidance from the experimenter. From the students' comments it was clear that they understood the notion of comparison, and were developing an understanding of controlled experimentation. These students, however, fluctuated on this last point, sometimes altering only one variable, other times altering two or more variables simultaneously. Students in this category received three points. Finally, students in category D demonstrated thorough understanding of the various concepts described above. These students received four points. The student's final score was the summation of the number of

points received on each portion of the assessment measure. All tests were coded by one of the authors. In order to establish interrater reliability, twenty tests were selected at random and were coded by the first author independently. Interrater reliability was 100 percent agreement on the coding classifications which resulted in 100 percent agreement on the scores.

Results

Initial results are concerned with the reliability of the written instrument used as the pretest, posttest, and retention test. Internal consistency reliability in the form of coefficient alpha was calculated for each test, using 107 cases. The values of coefficient alpha were 0.45, 0.68, and 0.73 for the pretest, posttest, and retention test, respectively. Descriptive results of the performance of LD, BD, and nonhandicapped students within each instructional condition on the pre- and posttests as well as the tests of retention and generalization are presented in Table 2.

Insert Table 2 about here

Three multiple linear regression analyses were performed on the data with the SPSSX program (SPSS, 1983). In the first analysis, the posttest was the dependent variable; in the second and third analyses, the dependent variables were the retention and generalization tests, respectively. A hierarchical regression model was employed to examine the separate influences of the pretest, treatment, group affiliation and two-way interactions of treatment with group affiliation variables. The pretest was entered into the regression equation on step one; two dummy variables, one representing treatment, the other representing group affiliation were entered on step two; the two-way interactions between treatment and group affiliation were entered on step three. Thus, the increase in variance explained in the dependent variable due to

the unique contribution of each predictor variable was estimated while controlling for all predictor variables entered on the same or preceding steps (Pedhazur, 1982). The results of these analyses are summarized in Table 3.

Insert Table 3 about here

Using the posttest as the dependent variable, considered alone on step 1, the pretest accounted for 25.44% of the variance in posttest scores ($F=35.83$, $p<.001$). When treatment and group affiliation were added to the regression equation in step 2, the R-square change for step 2, an additional 13.95%, was significant (F change = 4.60, $p<.001$). Only the pretest and group affiliation variables exhibited significant beta weights in the overall regression equation. Closer inspection of the group affiliation variable indicated that LD students did not perform as well on the posttest as other students (beta=-.30, $t=-3.73$, $p<.001$). Addition of the two-way interactions between treatment and group affiliation on step 3 added only another 3.06% of accounted variance to the overall regression equation. Moreover, the R-square change for Step 3 was not significant (F change =1.28, $p>.05$). With respect to the retention tests, the pretest alone on step 1 accounted for 12.66% of the variance ($F = 14.93$, $p<.001$). When treatment and group affiliation were added to the equation on step 2, the R-square change, an additional 16.87% was significant (F change = 4.69,$p<.001$). Treatment and group affiliation as well as the pretest exhibited significant beta weights in the overall regression equation. Inspection of the beta weights indicated that LD students, once again, did not perform as well as others (beta =-.33, $t=-3.74$, $p<.001$); and students who received the discovery teaching approach outperformed their direct instruction counterparts (beta =.19,$t=2.24$, $p<.05$). The addition of the two-way interactions between treatment and group affiliation on step 3 added only 4.20% more accounted variance. Moreover, the R-square change for step 3 was not significant (F

change =1.49, p>.05).

In the final regression analysis, the generalization test was the dependent measure. The pretest was significant and accounted for 7.38% of the variance (F change = 8.37, p<.01). Treatment and group affiliation, added on step 2, did not add significantly to the explained variance (R-square change = 5.00%,F change = 1.14, p>.05). The addition of the two-way interactions on step 3 added 14.31% more accounted variance (F change = 4.68, p<.01). Interpretation of the interaction terms indicated that LD students taught with the discovery approach outperformed LD students taught under the direct instruction condition (beta =.94, t=3.44, P<.001).

Conclusions

The authors were guided by four research questions: (1) Do mildly handicapped and nonhandicapped students exhibit greater science achievement under direct or discovery teaching? With respect to immediate achievement, neither direct nor discovery methods possessed an advantage for the youngsters in this study. (2) Do mildly handicapped and nonhandicapped youngsters retain achievement better under direct instruction or discovery teaching? In this study, students' retention after two weeks was higher for those who received the discovery instruction. It should be noted that learning disabled students as a group did not perform as well as the other groups of students on the posttest and the test of retention. Given the academic problems traditionally exhibited by LD students, this is not a surprising finding. (3) Do mildly handicapped and nonhandicapped students generalize a newly learned science processing skill better under direct instruction or discovery teaching? Whereas no treatment or group affiliation effects were found, the results do indicate that LD students in the discovery teaching condition outperformed their LD counterparts who received direct instruction. (4) Is the achievement of nonhandicapped children effected when they work with handicapped children in

direct instruction or discovery teaching? Nonhandicapped students in this study were not hindered when they worked with LD or BD students in a small learning group.

Discussion

The results of this study contribute to the literature in several ways. First, they challenge the notion that the teaching behavior typical of direct instruction systems creates the most effective learning environments for all curricular areas. Whereas direct instruction is successful, particularly for basic skill instruction in reading and mathematics, such teaching methods may be less beneficial for science. The relatively poor results of direct instruction reported here and elsewhere (e.g., Mastropieri, Scruggs, & Levin, 1985; Scruggs, Mastropieri, Levin, & Gaffney, 1985) must be carefully considered. For example, Rosenshine (1986) acknowledges the positive results of direct instruction on explicit procedures such as mathematical computation, reading decoding, and grammatical rules. However, he suggests that limits exist for the application of such teaching methods. When the knowledge is implicit, the task is less structured, the skills do not follow explicit steps, and the concepts are vague and entangled, Rosenshine argues that direct instruction is less appropriate. Teaching composition, analyzing literature, and developing entangled concepts such as `liberal' or `modernism' are examples that may best be accomplished by methods other than direct instruction (Rosenshine, 1986). The more important areas of science, such as process skill development, conceptual understanding, and problem solving have many implicit qualities. The widespread application of a single instructional approach such as direct instruction may not be the most advantageous for exceptional children. Research is needed to create links among specific instructional techniques, curricular areas, and the needs of handicapped students, particularly as those needs are manifested in the general education classroom.

Second, the results highlight the need for researchers to measure delayed as well as

immediate outcomes in intervention studies. The results of this study suggest that the superiority lies in delayed rather than immediate effects.

Finally, these results add to the literature regarding learning disabled students' ability to generalize newly acquired knowledge or skills to a novel task. The issue of generalization is critical for several reasons and is receiving considerable attention from those interested in the LD population. The ability to generalize a newly acquired skill or process over time and across tasks is a significant indicator that the skill or process has become a permanent member of the student's learning repertoire. In fact, to some the ability to generalize represents the ultimate measure of learning. Generalization represents yet another cognitive demand that is placed on students and is particularly difficult for the learning disabled population (Schumaker, Deshler, & Ellis, 1986) as well as other special needs students (Ellis, Lenz, & Sabornie, 1987). If the mildly handicapped are to be successful in the mainstream science classroom, they must be able to maintain knowledge across time and transfer it across contexts. These data indicate that for the learning disabled students discovery teaching was more effective in enhancing students' ability to generalize.

Implications for Teaching

In addition to the contributions discussed above, the conclusions from this study provide important information to teachers about the integration of mildly handicapped youth into science classes. These data suggest that the presence of a learning disabled or behaviorally disordered student in a small learning group does not hinder the achievement of the handicapped children. Such information provides support for continued investigation regarding the integration of handicapped students into general education science classes. If this finding is replicated, general education teachers may be more willing to accept students into their classes who exhibit learning and/or behavioral problems.

In addition, these data address classroom teachers' frequently expressed concern about the LD student's inability to generalize knowledge acquired in one unit of instruction to other aspects of the curriculum. Teachers have often lamented that LD students develop "islands of knowledge," each distinct from the next. The results of this study suggest that LD students' ability to generalize science process skills may be enhanced when taught through a discovery approach.

Finally, this study suggests to teachers that what constitutes "best practice" in one curriculum area (such as development of basic skills in reading and math) may not be the most effective instructional approach when teaching a different curriculum area (such as acquisition of science process skills). In an era where conflicting views as to what constitutes "best practice" abound, researchers and teachers must confront the challenge of determining paradigms of practice that are effective for use when teaching specific curriculum content to handicapped as well as nonhandicapped learners. This study is a first step in that direction.

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TABLE 1

Grade and Sex of Subjects by Group Membership

Grade	Gender	Group Membership					
		LD	BD	Nonhandicapped with LD Partner	Nonhandicapped with BD Partner	Nonhandicapped	TOTAL
Fourth	M	2	2	4	2	5	14
	F	-	-	1	3	6	10
Fifth	M	3	3	4	5	24	39
	F	3	-	7	1	16	27
Sixth	M	2	1	2	1	2	8
	F	-	-	3	0	6	9
Total		10	6	21	11	59	107

TABLE 2

Mean Performance Scores of Students by Treatment and Type of Group Membership

		Direct					Discovery		
Membership	n	Pretest	Posttest	Retention	Generalization	n	Pretest	Posttest	Retention	Generalization
Learning Disabled	6					4				
$\bar{X}$		8.33	9.67	10.00	5.83		8.50	13.50	14.25	10.75
SD		1.97	2.42	2.97	1.94		1.73	3.69	1.71	2.06
Behavior Disordered	2					4				
$\bar{X}$		8.50	13.50	12.00	9.00		9.25	16.00	16.00	7.75
SD		.71	.71	2.83	5.65		.96	.82	1.41	1.26
Non-Handicapped With LD Partner	12					9				
$\bar{X}$		9.08	15.50	15.82	6.75		9.44	15.89	16.22	8.67
SD		2.19	2.91	3.31	2.80		2.29	2.93	3.15	1.73
Non-Handicapped With BD Partner	4					7				
$\bar{X}$		7.75	12.50	13.00	8.00		8.57	13.86	15.00	6.00
SD		2.22	1.92	.82	1.15		3.04	3.39	2.61	4.24
Non-Handicapped	25					34				
$\bar{X}$		9.96	15.16	15.48	8.76		10.00	15.38	16.12	8.47
SD		2.30	2.49	2.40	1.79		3.47	2.92	2.92	1.81

TABLE 3

Summary of Hierarchical Regression Analyses of Post, Retention, and Generalization Test Scores

		Posttest			RetentionTest			GeneralizationTest		
Step	Source	Variance Increment	df	F Change	Variance Increment	df	F Change	Variance Increment	df	F Change
1	Pretest (A)	.2544	1	35.83***	.1266	1	14.93***	.0738	1	8.73**
	Residual	.7456	105		.8734	103		.9262	105	
2	Treatment (B) Group (C)	.1395	3	4.60***	.1687	3	4.69***	.0500	6	1.14
	Residual	.6061	103		.7047	101		.8762	100	
3	Two-way Interactions (BxC)	.0306	4	1.28	.0420	4	1.49	.1431	10	4.58**
	Residual	.5755	102		.6628	100		.7331	96	

***p < .001
** p < .01